GUIDELINES FOR THE DISPOSAL OF SULPHUR CONTAINING SOLID WASTE

Prepared by:
Industrial Wastes Branch
Standards and Approvals Division

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1. Introduction

Although the major impact of sulphur in the environment is related to gaseous sulphur-bearing emissions, the amounts of sulphur contaminated solid wastes is significant and procedures for proper disposal of these materials are required to prevent localized soil and groundwater degradation. Careless disposal of those wastes may result in acidification of both soil and groundwater.

This guideline will assist generators to dispose of sulphur containing solid wastes in an environmentally acceptable manner.

Sulphur contaminated wastes originate primarily from the sour gas sweetening industry and occasionally from accidental spills of sulphur during transport to market.

Sour gas sweetening with iron sponge or ironite slurry produces a waste product containing pyrite (FeS2), troilite (FeS) and sulphur (S). A similar process based on sweetening sour gas with an inorganic zinc compound generates zinc sulphide.

Spent catalyst from the modified Claus sulphur recovery process contains sulphates, sulphides and free sulphur.

In addition, sulphur recovery plants produce sulphur contaminated soil as a result of spills and operations associated with the sulphur storage blocks.

2. Disposal Methods

Disposal by burial or cultivation on the land is acceptable provided that steps are taken to neutralize the acids which are produced by biologically induced conversion of the sulphur in the soil.

2.1. Pit Burial

This relatively simple disposal method is applicable to all sulphur contaminated wastes, however watery waste must be pre-treated to a reasonably dry state.

The method consists of excavating a suitably sized pit above the water table, in an area underlain by clay or silt. The bottom and sides of the pit are then to be lined uniformly with limestone. The amount of limestone to be used will depend on the amount of sulphur in the waste. Each kilogram of sulphur requires 3.2 kilograms of limestone. When disposing of spent sour gas sweetening agents the amount of limestone required may be determined by the method presented in the Appendix.

After lining the pit with limestone, the waste is deposited in the pit, the waste is then covered with a layer of limestone in an amount equal to 10% of the amount used to line the pit and a final earth cover put in place. The top of the waste is to be at least one metre below the finished grade. Final surface grading should eliminate accumulation of surface water at the disposal site.

2.2. Surface Disposal

This method consists of applying the sulphur contaminated solid waste evenly across an area of land at a maximum rate of 2 tonnes of sulphur per acre. Either prior to or immediately following an application of the waste to a disposal area, the calculated amount of $CaCO_3$ (ground limestone) or $Ca(OH)_2$ (hydrated lime) should be spread evenly over this area of disposal to achieve pH control.

Using suitable tillage equipment, the waste and lime or limestone must be incorporated into the soil immediately after spreading.

When a small amount of sulphur contaminated solid waste is generated periodically the same area may be used for disposal a number of times before reaching a maximum 2 tonnes of sulphur per acre.

The disposal area should be used in a 3 or 4 year cycle; disposing of up to 2 tonnes of sulphur per acre on a given area every third or fourth year. During the years between disposal, the area should be either sown to a grass mixture or farmed in some way (should support vegetation). A regular soil sampling program should then be followed to ensure pH control.

Disposal via this method is not recommended during the winter as the potential for surface water contamination is significant since incorporation into the soil is not possible.

3. Approval Requirements

Disposal of sulphur contaminated solid waste is permitted through a Licence to Operate or a Letter of Permission issued by the Director of Standards and Approvals pursuant to provisions in the Clean Water Act. Persons wishing to dispose of this type 9fo waste must make application to the Director of Standards and Approvals for the required approvals. Applications forms and relevant information can be obtained by contacting the Standards and Approvals Division of Alberta Environment.

4. Effect of Sulphur on soil

Under aerobic soil conditions the application of sulphur to the soil results in the oxidation of sulphur to sulphate. That transformation is largely carried out through oxidizing bacteria which induce the following reaction:

$$S + 3/2\ 0_2 + H_20 \xrightarrow{bacterial\ action} H_2SO_4$$

The formation of two hydrogen ions as reaction products along with sulphate will lower the soil pH, and may result in increased acidity, higher soluble sulfate content of the soil, reduced concentration of Ca and other basic ions, reduced activity of micro-organisms, increased concentration of po9tentially toxic ions (Al, Mn), reduced availability of other nutrients (P), greater overall contribution of nutrients and potentially hazardous ions to surface and groundwater, and increased soil erosion. To mitigate this effect a neutralizing agent such as limestone may be used. The following reaction occurs:

$$H_2SO_4 + CaCO_2 \longrightarrow CaSO_4 + CO_2 = H_2O$$

When sulphur and lime are added to the soil the long term consequence is to produce calcium sulphate (gypsum) which is relatively benign in the soil environment. With gypsum being slightly soluble, salinity problems are unlikely to occur (2).

REFERENCES

1. Bertrand, R.A., "Reclaiming of Soils Made Barren by Sulphur from Gas Processing Plants", Thesis, University of Alberta (1973).

2. Graveland, D.N. and Kacsinko, F., "subsurface Disposal of Elemental Sulphur", Alberta Environment (1974).

APPENDIX

Calculation of required mass of limestone $CaCO_3$ or hydrated lime ($Ca(OH)_2$) to dispose of spent sweetening products

V is the total volume in cubic metres of H_2S absorbed in a batch of sweetening product. The H_2S molar volume at 0°C (273.15K) and 101.325 kpa is $22.4 \times 10^{-3} m^3$.

Assuming 15°C (288.15K) as the sweetening operation and the pressure constant and equal to 101.325 kPa, the mole volume v of H_2S will be:

$$V = 22.4 \times 10^{-3} \times \frac{288.15}{273.15} = 23.6 \times 10^{-3} m^3$$

The total moles of H_2S absorbed will be $\frac{v}{23.6 \times 10^{-3}}$ which, in the limit situation of all S^{2-} changed to SO^{2-} under action of soil oxidation conditions (Thiobacillus or other oxidant), will correspond to

$$\frac{V}{23.6 \times 10^{3}} mole \times \frac{100\ g/mole}{1000\ g/Kg} = 4.24 \times V\ Kg\ of\ CaCO_3$$

or

$$\frac{V}{23.6 \times 10^{3}} mole \times \frac{75\ g/mole}{1000\ g/Kg} = 3.14 \times V\ Kg\ of\ Ca(OH)_2$$

For safety use 5 V Kg of $CaCO_3$ OR 4 V Kg of $Ca(OH)_2$. This amount could be corrected for any $CaCO_3$ native to the soil. Either $CaCO_3$ or $Ca(OH)_2$ present similar long-term neutralizing ability, but $CaCO_3$ has advantages in keeping the soil pH within a range that promotes normal plant growth. When $Ca(OH)_2$ is applied at rates above those required for immediate soil neutralization, the pH is raised to a point that may inhibit plant growth (1).

The use of dolomitic limestone should be carefully assessed because of salinity problems associated with the solubility of magnesium sulphate.